

Continuing Proposal

**Evaluation of Adult Salmon and Steelhead Migrations Past Dams and Through Reservoirs in the
Lower Columbia and Snake Rivers and into Tributaries**

To

Walla Walla District, U. S. Army Corps of Engineers
Walla Walla, Washington

By

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Research Pre-Proposal

EVALUATION OF WEIR AND FISHWAY MODIFICATIONS IN THE TRANSITION POOL TO IMPROVE PASSAGE OF ADULT SALMON AND STEELHEAD PASSING LOWER GRANITE DAM - 2005

Project Summary

A. Goals

The goal of this study is to evaluate the effectiveness of weir and fishway modifications to improve passage conditions for adult salmon and steelhead passing Lower Granite Dam. Modifications, scheduled to be made during winter of 2004-2005, are intended to improve flow dynamics and attractiveness for fish passing through the transition pool area of the Lower Granite Dam adult fishway. This study would be a continuation of previous research for the Adult Anadromous Fish Passage Project for the Lower Columbia and Snake rivers funded by the Walla Walla District, U.S. Army Corps of Engineers (USACE) under Contract No. DACW68-01-D-0006 and associated with Study Code ADS-00-1.

B. Objective - 2005

1. Evaluate effectiveness of weir and fishway modifications to improve passage through transition pool at Lower Granite Dam for adult salmon and steelhead.

C. Methods

The research outlined here is a collaborative effort between personnel from the University of Idaho, Idaho Cooperative Fish and Wildlife Research Unit (ICFWRU) and NOAA Fisheries. Project leaders will be responsible for preparation and submission of all project proposals and respective work plans. ICFWRU personnel will secure research permits, install, maintain and download telemetry equipment. NOAA personnel maintains the telemetry databases from previous years in Seattle (Funding for stated NOAA portion of the studies provided directly through Portland District USACE). ICFWRU personnel will code the telemetry records to define and report on movements and behavior of the fish and maintain related databases in Moscow.

Modifications to the transition pool area at Lower Granite Dam will be made by COE contractors during the winter of 2004-2005. Adult Chinook salmon and steelhead collected at Ice Harbor Dam, outfitted with transmitters, and released to the river upstream from the dam will be monitored as they pass Lower Granite Dam using the existing receiver and antenna array at the dam. Passage times and behavior of fish in the transition pool, and overall passage times at the dam during 2005, will be compared to data collected before 2000, prior to weir modifications, and to those data collected during 2000-2003 with prototype weir modifications in place.

Project Description

A. Background

Adult salmon and steelhead migrating to their natal streams in the tributaries of the Columbia River must pass up to eight dams and their reservoirs, four each in the lower Columbia and Snake rivers. Stress, delays, and losses during migration at each hydroelectric project and associated reservoir must be minimized to succeed in maintaining the native runs of fish and achieve the recovery goals outlined by the Northwest Power Planning Council (NWPPC) and by NOAA Fisheries.

Median times for adult salmon and steelhead to pass Columbia and Snake River dams can range up to 24 to 30 h, with some fish taking 5 d or more to pass individual projects (Keefer et al. *In press*). A significant portion of time to pass dams can be used to successfully negotiate transition pools at the base of ladders, especially for fish that leave the transition pools and exit to the tailrace one or more times before eventually passing the dam. Typically over half of the adult migrants we have monitored reversed course in transition pools and exited fishways at Columbia and Snake River dams (e. g. Bjornn et al. 1998; Bjornn et al. 2000; Keefer et al. 2003a). It is unknown why this area in the fishways, where flow down the ladders meets the less turbulent flow at the head of the collection channel or entrance from the tailrace, disrupts fish passage. Factors that may impede fish movement include: the low velocities through the transition pool area relative to velocities at fishway entrances and in the ladders, non uniform flow direction caused by water added to the fishway at diffuser grates, submergence of the first few weirs of the ladders when tailwater elevations are high, or temperature discontinuities (Peery et al. 2003). Time to pass dams for up to two-thirds of the fish could be reduced if passage through the transition pools was more efficient and fewer fish exited the fishways into the tailrace.

There is evidence that adult salmon and steelhead prefer to pass weirs in the ladders through the submerged orifices rather than over the weirs. But when weirs at the bottom of the ladders are submerged because of high tailwater levels, flow through orifices of the weirs is reduced. In 2000, the bottom five weirs in the ladder at Lower Granite Dam were modified to increase the head at the weirs and thereby increase velocities through submerged orifices, to determine if fish would pass through the transition pool more rapidly. The modification increased the height of the center non-overflow section of the weirs and provided the capability to add vertical panels as needed to reduce the width of the overflow section. These modifications allowed us to maintain a head differential of 0.25 to 1 ft at each weir in the lower end of the ladder, and thereby forced more water through the orifices of submerged weirs. A head of 0.25 ft produces a velocity of about 4 fps through the submerged orifices. Weirs were modified by mid-May 2000 and were in operation during the passage of spring/summer chinook and fall chinook salmon, and steelhead. There was evidence that passage times were faster in 2000 and that fewer fish exited the fishway into the tailrace, but passage rates were also faster at other dams (i.e. Little Goose Dam) compared to earlier years.

Because of the difficulties of comparing data between years, in 2001 and 2002 the study design was changed to a paired-treatment test comparing passage with high and low head levels at the first two weirs in the transition pool. The test consisted of comparing fish passage at a high head level of about 1 ft (all vertical panels in place) with a low head level (all but the first panels removed) at the first two weirs in the fishway. At the completion of that test we compared passage success (proportion of fish that pass through transition pools on first attempt) and passage times between the high and low head/velocity conditions. We found that a greater proportion of fish passed through transition pools on their first attempt, and median transit times through the

transition pool were lower, when the prototype weir modification was fully deployed (Naughton and Peery 2003).

Based on results from the 2000-2002 evaluations, permanent modifications to the Lower Granite fishway to improve passage through the transition pool area were developed. The proposed modification consists of two components, 1) narrowing the width of the junction pool area between the transition pool and the south end of the collection channel to increase velocity and directional flow of attraction water through this segment of the fishway (Figure 1), and 2) modify the shape of the first eight weirs in the ladder to produce target velocities of 2.5 to 3.0 fps (head differential of 0.8 to 1.2 ft per weir) through submerged orifices (Figure 2). Construction to install modifications is scheduled to occur during the winter of 2004-2005.

Modifications to the fishway at Lower Granite Dam would be evaluated by monitoring a sample of adult Chinook salmon and steelhead outfitted with radio transmitters at Ice Harbor Dam. At Lower Granite Dam, an array of telemetry receivers and antennas will be used to monitor movements of radio-tagged salmon and steelhead as they move through the fishway, particularly the transition pool and bottom of the ladder. Fish behavior and performance during 2005 will be compared to that from previous years of monitoring prior to modifications and during testing of prototype modifications.

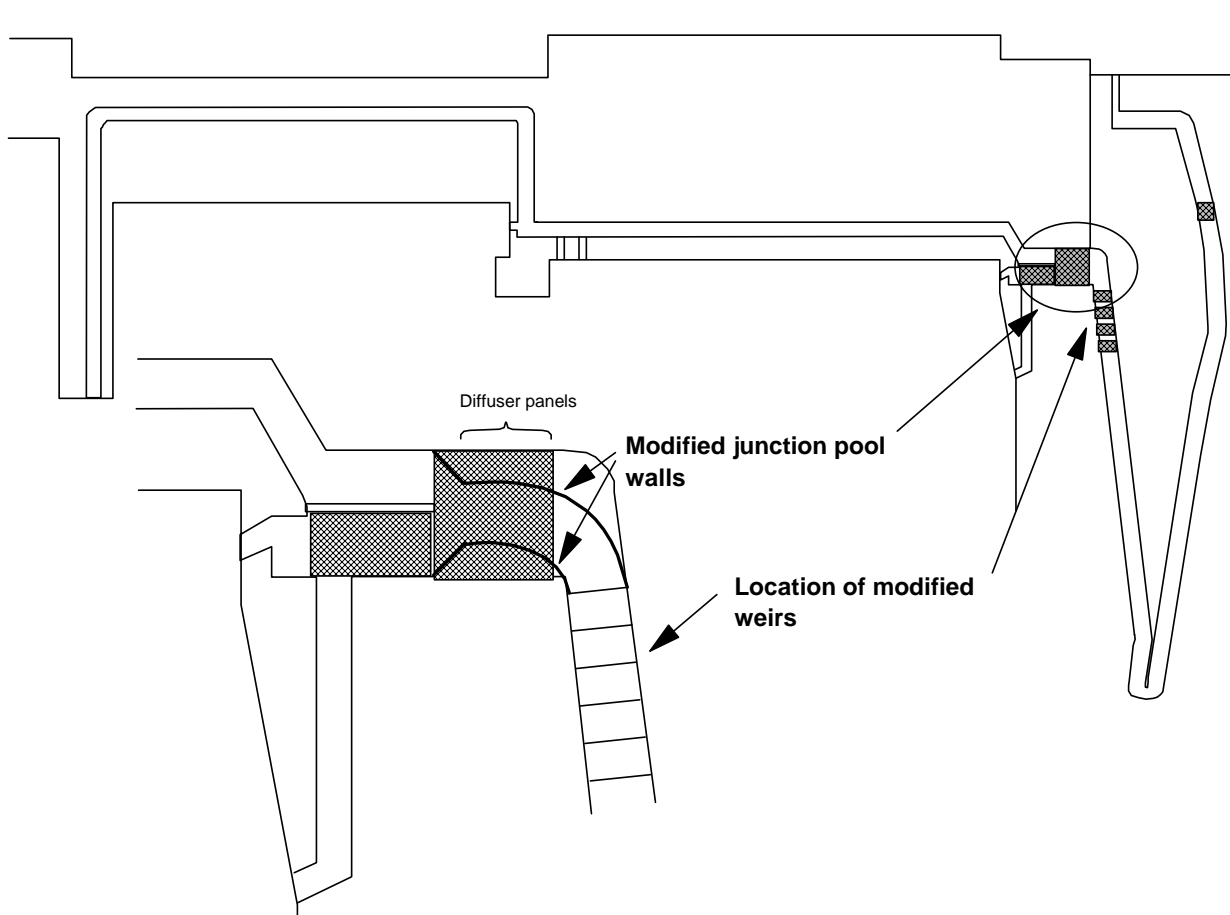


Figure 1. Drawing of Lower Granite Dam and fishways and detail of modification to junction pool walls.

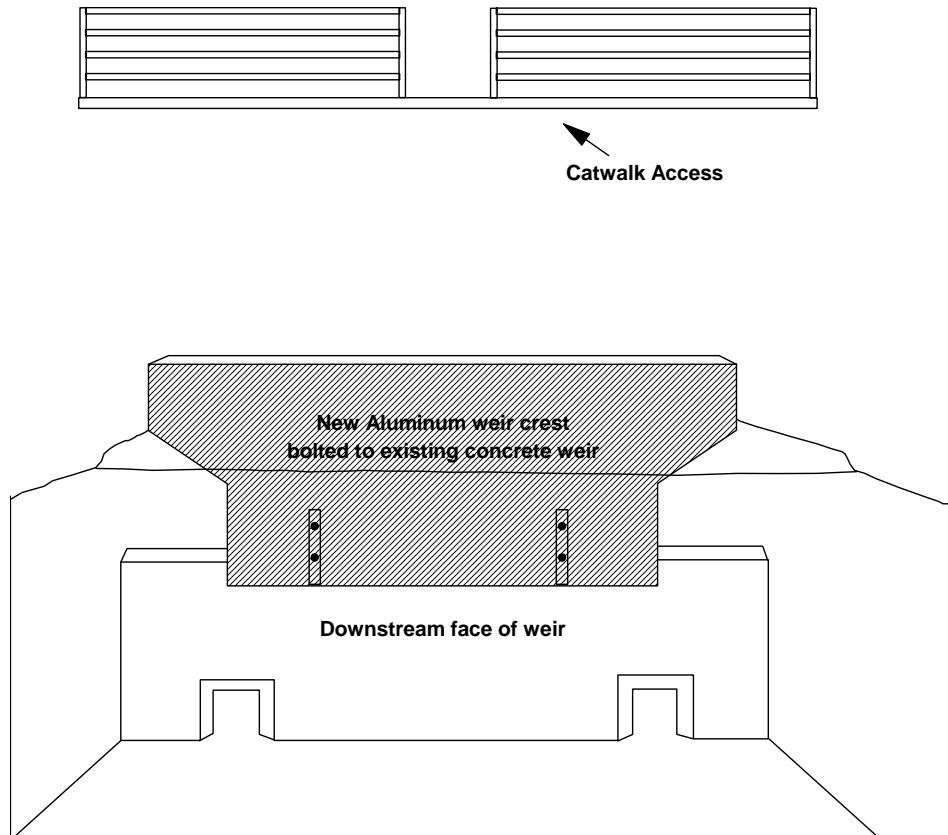


Figure 2. Example of proposed weir modification to be added to first eight weirs in Lower Granite Dam adult fish ladder (transition pool area).

This proposal was developed in response to requests for preliminary proposals issued by the U.S. Army Corps of Engineers (CORPS) in July 2004, and addresses concerns of the CORPS, the NWPPC in the Columbia River Basin Fish and Wildlife Program, and by NOAA Fisheries in the Proposed Recovery Plan for Snake River Salmon, and Biological Opinion issued in 2000 (which supercedes the 1995 and 1998 Biological Opinions). The proposals have been developed in consultation with personnel from the CORPS and NOAA Fisheries.

The study proposed here is a continuation of monitoring and evaluation of adult salmon and steelhead passage and survival through the Columbia and Snake River hydrosystem conducted in recent years to develop means to improve passage efficiency. Reports from previous year's research are available at <http://www.cnr.uidaho.edu/uiferl/>. Evaluations of adult salmon passage through the lower Snake River by University of Idaho and NOAA Fisheries began in the early 1990's (Bjornn et al. 1998, Bjornn et al. 1999, Bjornn et al. 2003) and included studies of the lower Columbia River beginning in 1996 when fish were collected and outfitted with transmitters at Bonneville Dam (Bjornn et al. 2000; Keefer et al. 2002; Keefer et al. 2003b). We will continue to process data and develop summaries for previous task orders on this contract. Specifically we will be addressing the relationship between passage times and escapement probability, sources of loss in the system, and development of predictive models for fallback, straying and survival. Data collected during 2005 will be processed and analyzed during 2005 and a final report will be available mid-2006.

B. Objective - 2005.

1. Evaluate effectiveness of weir and fishway modifications to improve passage through transition pool at Lower Granite Dam for adult salmon and steelhead.

C. Methods

For this study, we propose to tag a sample of adult spring and summer Chinook salmon and steelhead at Ice Harbor Dam, release them to the river upstream from the dam, and monitor their behavior and passage as they pass Lower Granite Dam. Methods for collecting and tagging fish at Ice Harbor Dam, downloading of data from receivers, and processing of the data will be similar to those developed in prior years (see below). Computer programs previously developed for processing the data and getting it into summary form for analysis and report preparation will be used.

C.1 Sample Size.

Numbers of fish needed to adequately describe dam passage (passage times, passage success, entrance use, etc.) varies with the complexity of the project (i.e. numbers of possible entry and passage routes) and variability on the data. In general, at relatively simple projects such as the upper three Snake River dams, a minimum of 200 fish per run is needed to provide baseline descriptions of passage behavior (i.e., proportion of fish that pass, total median passage time, etc.), ensuring that no individual fish makes up more than 0.5% of the sample. However, because telemetry monitoring (like most sampling techniques) is not 100% effective, the sample size should be increased by approximately 20% to 25%, to 240 to 250 tagged fish per run to compensate for fish that miss being detected at individual receiver/antenna sites. Snake River projects are smaller and relatively simple in design than those on the Columbia River. In addition, fallback rates are lower, and the variability in many fish behaviors is relatively low (for example, see Table 1). Any within-season comparative studies (e.g., survival of fish that do and do not fallback, behavior of fish with and without transition pool modifications) also necessitate larger samples (approximately double) so sufficient numbers of fish will occur in each comparison group. Using power analysis, we estimate a sample of 400 fish would be needed to detect a 25% difference in performance between two treatment conditions at the alpha 0.05 level and with a power of 0.80. The estimated sample size increases to 620 fish if the detectable distance is reduced to 20%.

For the proposed study, the comparison group(s) would be fish monitored during 2005 and previous years of study, so half the estimated sample size (200 to 310 fish) per group would need to be monitored at Lower Granite Dam during 2005. Escapement between Ice Harbor and Lower Granite Dam is relatively high, averaging 97.7% for spring-summer Chinook salmon and 90.2% for adult steelhead (Keefer et al. *In review*). In more recent years, escapements between the two dams have been slightly higher, about 98% for Chinook salmon and 92% for steelhead. Adjusting fish tagged by these percentages produces sample sizes of 204 to 316 Chinook salmon and 217 to 337 steelhead. As noted above, some fish may not be recorded when passing some individual receiver and antenna locations. Possible causes are that fish may swim through the detection range of an antenna between transmitter signals (typically 5 s burst rates), external electronic noise interferes with a fish's transmitter signal, or because of a malfunction in detection equipment. Because of the narrow focus of the proposed study, monitoring a relatively small group of fish at a single project, we believe boosting samples by 10% should be sufficient to offset this potential

occurrence of non-detections. This equates to an estimated sample size of 226 to 351 Chinook salmon and 241 to 374 steelhead tagged at Ice Harbor Dam, or a total of 467 or 725 total fish tagged during 2005. The difference of 258 fish tagged between these low and high sample sizes would produce an estimated improvement of detectable difference of 5% (from 25 to 20% minimum detectable effect). These estimates of sample size fall within the range of the number of fish used for evaluations at Lower Granite Dam during previous years, about 200 to 350 individuals per group.

Table 1. Sample size (N), median (Med.) dam passage times (days), and standard deviations (SD) for radio-tagged spring–summer Chinook salmon monitored in 1997. A total of 1014 spring/summer Chinook salmon were tagged and released downstream from Bonneville Dam.

	Bon	TDalles	JDay	McNary	IHarbor	LoMo	LiGo	LoGr
N	901	555	527	320	276	289	263	274
Med.	1.0	1.3	1.5	0.7	0.8	1.0	0.9	1.1
SD	3.9	4.4	5.2	3.4	6.1	4.5	3.3	2.3

C.2 Fish Collection and Tagging

Adult fish to be used for this study would be collected using a removable trap at the south shore ladder at Ice Harbor Dam. Screens will be lowered into the V-weir opening in the top pool of the ladder to guide fish through the trap box where they can be observed and selected for tagging, or allowed to continue their migration. Fish of a suitable size will be diverted from the trap box into an adjacent holding pen where they will be held until the number needed is collected. The holding pen will be lifted by crane to the top forebay deck and the fish will be drained into a transport tank on a truck or trailer. The lower 45 cm of the holding pen is constructed of sheet metal to retain water when lifted from the ladder so fish are always in water. A canvas sleeve attached to a hole in the bottom of the holding pen will be used to transfer fish from pen to transport tank. The transport tank will be filled with water from the forebay and a mild anesthetic to keep the fish calm and to prepare them for transport and tagging.

Fish will be transported to a boat ramp, approximately 1 km upstream from the dam. Once there, each fish will be placed into a vinyl-coated sleeve and moved to a smaller tank filled with full-strength anesthetic where lengths, weights, and presence of marks and injuries will be recorded, and the fish will be tagged. Each fish will receive a radio transmitter inserted into the stomach through the mouth and a PIT tag injected into the abdomen, if one is not present. Tagging generally requires about 6 min per fish and the fish are anesthetized and submerged at all times except when moved between tanks and when measured for length. After all fish are tagged, they will be individually placed into a pen in the river to recover. Fish will be kept in the recovery pen until they swim volitionally from the pen. The holding period is to allow full recovery from anesthesia and to check for transmitter retention. Fish usually swim away from the holding pen and out of view immediately after release. No "jack" salmon will be tagged. Fish will not be tagged when water temperatures exceed 72°F according to Fish Passage Plan (FPP) protocols.

Tagging operations will occur 4 d per week. Tag periods will coincide with the peak period when Chinook salmon or steelhead are passing Ice Harbor Dam (Figure 3). Chinook salmon would be tagged from mid-April through June while steelhead tagging would occur during August–October. All tagging operations will be completed by noon of each day.

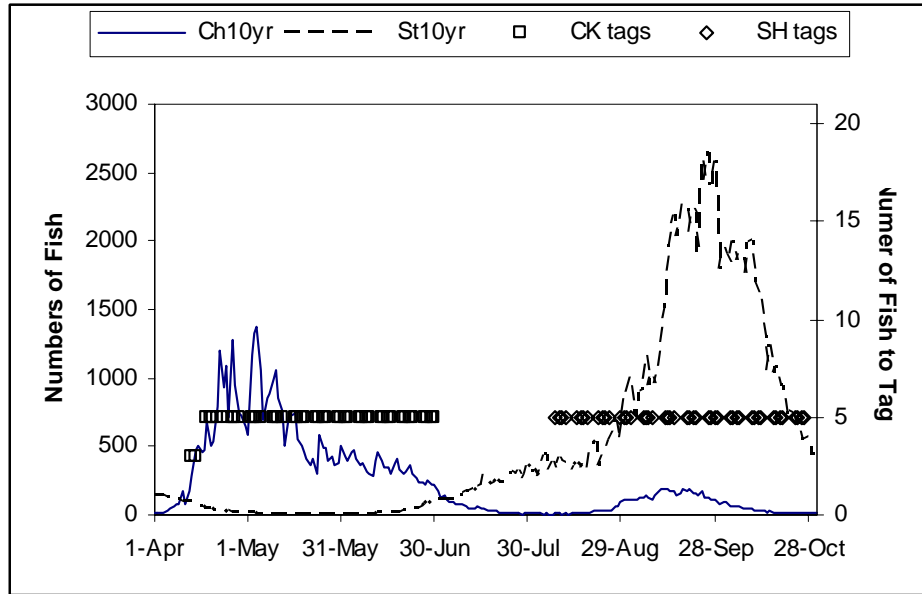


Figure 3. Proposed tag schedule for Ice Harbor Dam and ten-year average counts for adult salmon and steelhead at the dam.

C.3 Telemetry Monitoring

We propose to use 3- and 7-volt transmitters, that emit a digitally coded radio signal (containing the frequency and code of the transmitter) every 3 s. All transmitters were cylindrical with 43-47 cm antennas. The 7-volt transmitters weigh 29 g in air, 13 g in water (8.3 by 1.6 cm), 3-volt transmitters, used in fish 50 to 65 cm fork length, weigh 11 g in air, 4.1 g in water (1.4 by 4.3 cm). Code sets will allow us to monitor up to 523 fish on each frequency. The smaller 3 volt transmitters will be used in the smaller ("A-run") steelhead.

Tagged fish will be released upstream from Ice Harbor Dams and be monitored as they reach and then pass Lower Granite Dam. The final number and location of receivers and antennas used at Lower Granite Dam will be similar to that used in previous years to provide comparable data. Two SRX sequentially scanning receivers with yagi aerial antennas, one on each shore, will be used to determine when fish first enter the tailrace area at the dam. Digital spectrum processors (DSP) added to SRX receivers can simultaneously monitor several frequencies and will be used with coaxial cable underwater antennas to monitor all major fishway entrances, the junction pool, transition pool, and the fishway exit. All receivers record and store transmitter channel and code, relative power of signal, antenna receiving the signal, date and time. Stored information will be downloaded from receivers to computers approximately every 1 to 2 days.

We will coordinate with all research groups using radio telemetry for both adult and juvenile salmon, steelhead, and other fishes to insure efficient use of the equipment and resources available. As in past years, we will coordinate use of transmitter frequencies and codes by all groups using radio telemetry in the study area to prevent duplicate use of frequencies and codes that would lead to confounded data.

Radio telemetry receivers will be maintained and returned to the manufacturer, for repairs and updates, prior to the 2005 field season. All required receivers and antennas will be installed prior to the start of tagging of spring Chinook salmon in April of 2005.

C.4 Telemetry Data Processing and Analyses

Downloaded data files will be screened to remove obvious errors and records produced from electronic background noise and then loaded to the database. Once each dataset is complete, the telemetry data will be coded. Coding involves inspection of all records for a fish and assigning a code to appropriate records that defined behavior of a fish (e.g. first passage of the tailrace receiver, entrance or exit from a fishway). The initial data coding is performed using an automated program (Visual Basic). Coded records are then inspected for accuracy and incorporated into the main database to be used for data analyses.

Data collected at Lower Granite Dam during 2005 will include total time for fish to pass the dam, from first detection of fish in the tailrace until last record of fish at top of the ladder, and times for fish to transit each segment of the fishway: tailrace until first approach at a fishway entrance, first entry to a fishway, first entry to the junction pool, first entry to the transition pool area, first entrance into the ladder, and time to ascend the ladder (from the last exit of the transition pool until exiting the top of the ladder). Times and behavior of the fish within the junction pool and transition pool areas will also be categorized to identify proportion of fish that transit these areas on first attempts or reverse direction of movement and exit areas one or more times before eventually passing the dam. Results from 2005 monitoring will be compared to similar types of passage indices derived from data collected during 1996-1998 (three years for Chinook salmon and two years for steelhead) prior to the evaluations of the prototype weir modifications, and during 2000-2004 when prototype weir modifications were either fully or partially in place (the “down” and “up” panel paired treatments). Chi-square, ANOVA, and time-to-event analyses will be used to compare data from the different treatment groups. We will attempt to control for inter-annual variation in flow, temperature, and date of passage by incorporating these as covariates into analyses.

D. Facilities and Equipment

Radio telemetry equipment used during 2005 will be similar to that used in 2004 with updates and repairs made as required. The required number of transmitters will be ordered by late 2004 after consultation with CORPS personnel to insure delivery for the 2005 field season. Computers, vehicles, and other necessary equipment will be supplied by the researchers as needed on a rental basis. Installation of new antennas and repairs to existing antennas will be made during the winter maintenance periods at the dam, and will be completed prior to commencement of tagging in spring of 2005.

E. Impacts of study on USACE projects and other activities

Division or district USACE personnel will be needed to provide technical review of research proposed for 2005.

Assistance from project personnel will be required as follows:

1. Provide electrical power supply at Lower Granite Dam for electronics gear that will be used in the fishway and tailrace area during 2005.
2. During the 2004-2005 fall and winter maintenance period we will inspect and repair antennas at each of the dams and will need access to the fishway.
3. Provide access to tailrace and fishway, including transition pool area, for regular downloading of radio receivers and measurement of environmental variables during the study period.

4. Provide access to trap facility at Ice Harbor Dam for repairs and/or modifications prior to 2005 field season and for operation during sampling period.

F. Biological Effects:

Fish for studies outlined here would be collected and tagged at Ice Harbor Dam during 2005. Fish will be delayed for a period of several hours while they recover from effects of anesthesia.

G. Key Personnel

Project planning, administration, reporting:
 Principle investigators, C. A. Peery, UI
 B. J. Burke, NOAA Fisheries**
Work plan preparation, protocols, computer programs, permits:
 C. Peery, G. Naughton, UI
Equipment specifications and purchase:
 T. Dick, A. Snider
Tagging of fish
 S. Lee
Monitoring of receivers at dams and downloading data
 T. Dick, M. Morasch
Database management
 B. Burke, K. Frick, NOAA Fisheries**
Data coding
 M. Jepson
Analysis of data and preparation of report segments
 C. Peery, G. Naughton

**Costs associated with activities conducted by personnel from NOAA in association with this research project will be covered under separate funding agreements with USACE.

H. Reporting Schedule

Information and analyses from this study will be provided regularly to managers via reports and verbal presentations. Progress reports or presentations of results will be provided at up to three meetings, as requested by the POC and oral presentations summarizing 2005 field effort will be provided at the Annual AFEP Review. Additional information, updates, summaries, etc., will be provided for other managers as needed and when time allows.

A draft report of this study would be completed March 2006. The final report should be completed approximately 30 days following receipt of USACE review comments on the draft report.

Information that is appropriate will be published in peer-reviewed journals.

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